

RADIO FREQUENCY SYSTEMS

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MILLIMETER WAVES STUDY

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FOREWORD

The following report summarizes the progress of the Auburn University Electrical Engineering Department under the auspices of the Auburn Research Foundation toward fulfillment of the requirements prescribed in NASA Contract NAS8-11184. Monthly progress reports have been submitted prior to this report. Contract progress has also been reviewed by telephone and in meetings with Mr. T. A. Barr, Contract Supervisor, National Aeronautics and Space Administration, Huntsville, Alabama, and the participating Auburn University personnel.

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INTRODUCTION

Developmental work continued on the 2280-MHz television exciter unit. Temperature testing of the 380-MHz oscillator indicated that some form of temperature compensation was necessary if a stable output frequency was to be obtained.

The design of the power amplifier was modified into a common-base transistor configuration to provide better isolation between the oscillator and the X6 multiplier.

The packaging of the 28-vdc power supply for the exciter unit was initiated. The space available in the exciter unit package for the power supply requires a reduction in the total volume of the model received from NASA Astrionics at Huntsville.

Progress on the Millimeter Waves Study is reviewed in the final section of this report.

I. RADIO FREQUENCY SYSTEMS

A. Television Exciter Unit

1. Oscillator

Temperature testing was begun on the 380-MHz oscillator of the 2280-MHz television exciter unit. The results obtained indicated that some changes had to be made in the circuitry to stabilize the output frequency of the oscillator. While compensation work was initiated on the 380-MHz oscillator, a parallel effort was begun on a combination 190-MHz oscillator and doubler stage to try to gain improved frequency stability.

It was decided to use a Clapp-Gouriet circuit as the basic 190-MHz oscillator. This type of circuit yields good frequency stability against changes in transistor junction capacitance. An experimental model of this oscillator along with its associated doubler was constructed and tested. The schematic diagram of this circuit is shown in Figure 1.

Temperature tests indicated that the frequency of the uncompensated oscillator decreased with an increase in temperature. This suggested the possibility of using negative temperature coefficient capacitors in the tank circuit of the oscillator. Capacitor C6 was selected to add temperature stability to the circuit. The results of the temperature test after the addition were not completely satisfactory.

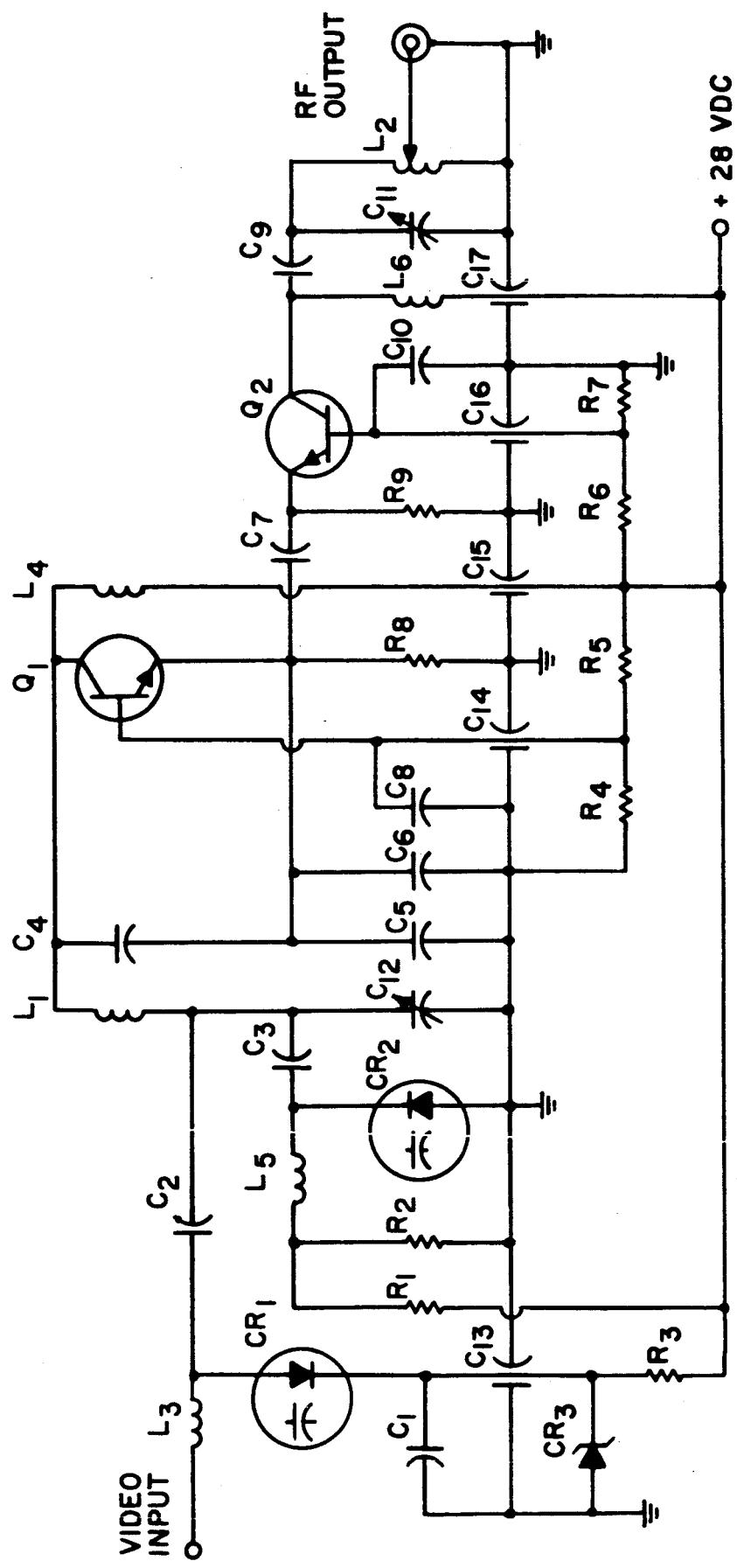


Fig. 1--Schematic diagram of the oscillator-doubler.

TABLE I
CIRCUIT VALUES FOR THE OSCILLATOR-DOUBLER

Circuit Component	Component Value
R ₁	Fixed wirewound resistor, 7500 ohm, 1 watt.
R ₂	Silicon resistor, 1200 ohm, 1/8 watt.
R ₃	Fixed wirewound resistor, 250 ohm, 1 watt.
R ₄	Fixed wirewound resistor, 100 ohm, 2 watt.
R ₅	Fixed wirewound resistor, 470 ohm, 2 watt.
R ₆	Fixed wirewound resistor, 400 ohm, 2 watt.
R ₇	Fixed wirewound resistor, 70 ohm, 1 watt.
R ₈	Fixed wirewound resistor, 225 ohm, 1/2 watt.
R ₉	Fixed wirewound resistor, 50 ohm, 1/2 watt.
C ₁ , C ₇ , C ₈ , C ₉ , C ₁₀	Fixed ceramic capacitor, 1000 pf. 250 wvdc.
C ₂	Fixed mica capacitor, 8 pf., 500 wvdc.
C ₃	Fixed mica capacitor, 5 pf., 500 wvdc.
C ₄	Fixed mica capacitor, 10 pf., 500 wvdc.

TABLE I
(continued)

Circuit Component	Component Value
C ₅	Fixed mica capacitor, 39 pf., 500 wvdc.
C ₆	Ceramic capacitor, negative temperature coefficient, selected value.
C ₁₁ , C ₁₂	Variable air capacitor, 0.8-8 pf., 800 wvdc.
C ₁₃ , C ₁₄ , C ₁₅ , C ₁₆ , C ₁₇	Fixed ceramic feedthru capacitor, 470 pf., 500 wvdc.
L ₁	Fixed inductor 0.081 microhenry.
L ₂	Strip inductor, 1/4" strip of brass in the shape of a "L". The dimensions are 5/8" x 3/8" x 5/16".
L ₃	R.F. choke, 0.82 microhenry, 1/4 watt.
L ₄	R.F. choke, 0.84 microhenry, 1/4 watt.
L ₅	R.F. choke, 1.0 microhenry, 1/4 watt.
L ₆	R.F. choke, 0.2 microhenry, 1/4 watt.
Q ₁ , Q ₂	Transistor 2N3375.
CR ₁	Varactor diode PC117.
CR ₂	Varactor diode MA4273C.
CR ₃	Zener diode PS1503A.

Further investigation showed that the method used to frequency modulate the oscillator could also be used in temperature compensation. The positive temperature coefficient resistor R_2 in the biasing network of the varactor diode CR_2 changes the capacitance in the resonant circuit of the oscillator in such a manner as to lessen the effects of temperature on the oscillator stability.

The doubler stage of the oscillator-doubler sub-assembly derives its input from the voltage across resistor R_8 through the coupling capacitor C_7 . The collector circuit of transistor Q_2 is tuned to 380-MHz by the resonant circuit elements, capacitor C_{11} and the strip inductor L_2 .

2. Power Amplifier

In order to facilitate matching between the oscillator-doubler and the X6 multiplier, a new power amplifier employing the common-base transistor configuration was designed. The common-base configuration provides better isolation between input and output than the common-emitter type amplifier. The schematic of the circuit that was designed and built is shown in Figure 2. The portion of the circuit composed of inductors L_1 and L_2 , capacitors C_1 and C_5 , and transistor Q_1 presents fifty ohms at 380-MHz to the output of the oscillator. Inductors L_5 and L_6 are r-f chokes. Capacitor C_6 places the base of transistor Q_1 at r-f ground potential. Resistors R_1 , R_2 , and R_3 are used in the d-c biasing of transistor Q_1 . The output network, composed of capacitor C_4 and inductors L_4 and L_3 , matches the power amplifier to the input of the X6 multiplier.

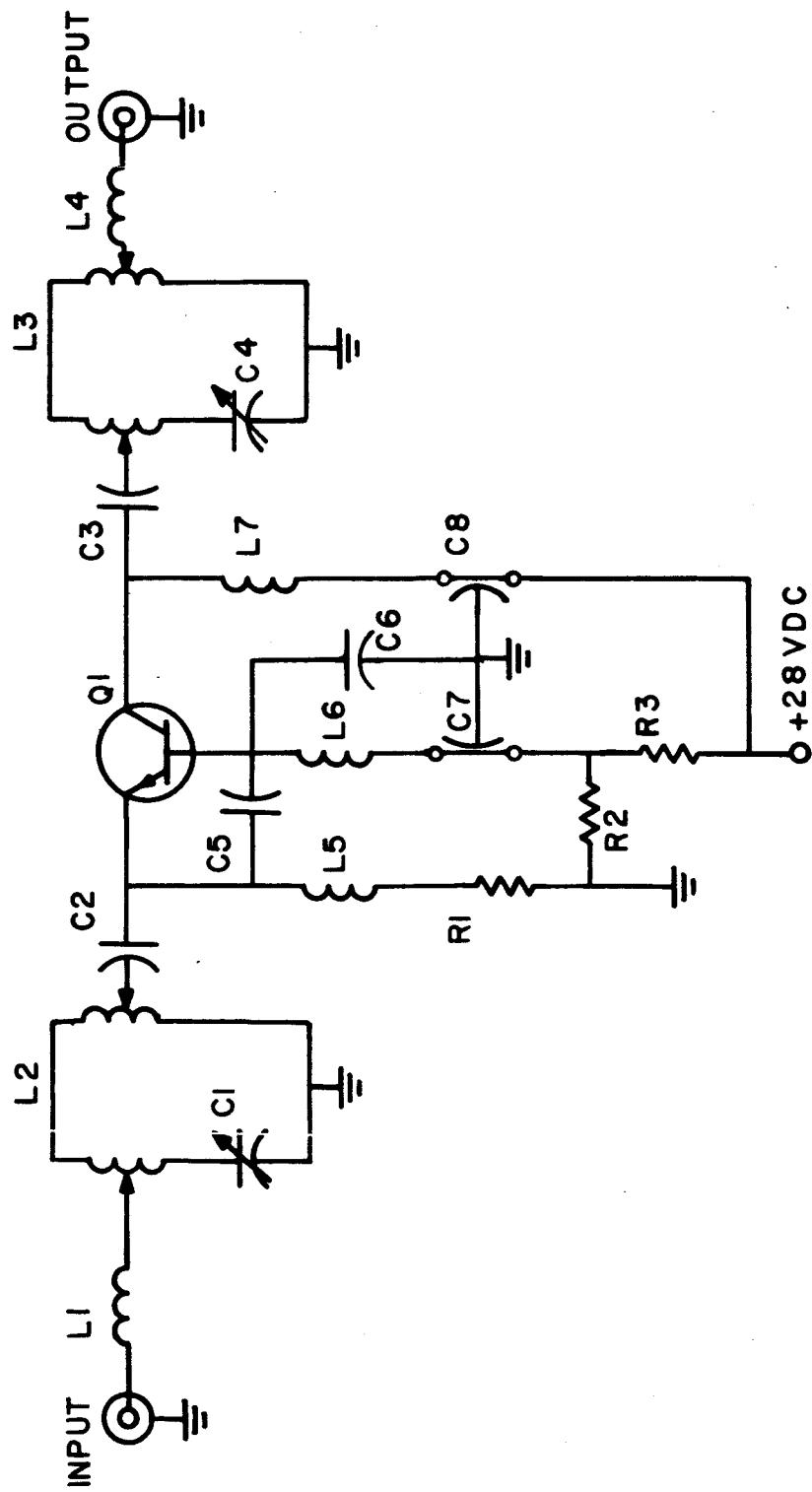


Fig. 2--Schematic diagram of the common-base transistor amplifier.

TABLE 2
CIRCUIT VALUES FOR THE COMMON-BASE TRANSISTOR AMPLIFIER

Circuit Component	Component Value
R ₁	Fixed carbon resistor, 100 ohm, 1/4 watt.
R ₂	Fixed carbon resistor, 10 ohm, 1/2 watt.
R ₃	Fixed carbon resistor, 820 ohm, 1 watt.
L ₁ , L ₄	Strip inductor, 1/4" strip of brass in the shape of a "L". The dimensions are 1/2" x 3/8".
L ₂	Strip inductor, 5/16" strip of brass in the shape of a "L". The dimensions are 1 1/2" x 7/16" x 3/8".
L ₃	Strip inductor, 0.025" strip of brass in the shape of a "L". The dimensions are 1 1/8" x 7/16" x 3/8".
L ₅ , L ₆ , L ₇	R. F. choke, 0.2 microhenry, 1/4 watt.
C ₁ , C ₄	Variable air capacitor, 0.8 to 8 pf.
C ₂ , C ₃ , C ₆	Fixed ceramic capacitor, 1000 pf., 250-vdc.
C ₅	Fixed mica capacitor, 20 pf., 500-vdc.
C ₇ , C ₈	Fixed ceramic feedthru capacitors, 470 mfd, 500-vdc.
Q ₁	Transistor type 2N3375.

The amplifier exhibits a power gain of 2.5, yielding a power output of one watt with a power input of 400 milliwatts. The flat portion of the amplifier bandwidth is approximately 28-MHz with a center frequency of 380-MHz.

3. Power Supply

The 2280-MHz television exciter unit establishes a requirement for a solid-state power supply that can supply an output of 28-vdc with a regulation of 0.1 percent and a maximum current of 750 milliamperes. The power supply that is used was designed by the Electrical Systems Division of NASA Astrionics at Huntsville. A bench model of the power supply was received.

Repackaging was initiated to eliminate nine cubic inches of volume in order that it would be compatible with the space available in the exciter unit package.

The operation of the power supply may be explained by first dividing the power supply into three sections: voltage-controlled oscillator, series regulator, and the starting circuit. The basic circuit of the power supply is shown in Figure 3. The VCO provides a pulse of fixed width to drive transistor Q₃, in Figure 3. With the use of feedback, the pulse repetition rate of the VCO is varied according to the power demand at point A in Figure 3. This feedback loop enables a voltage with a regulation of approximately ± 2 percent to be established at point A.

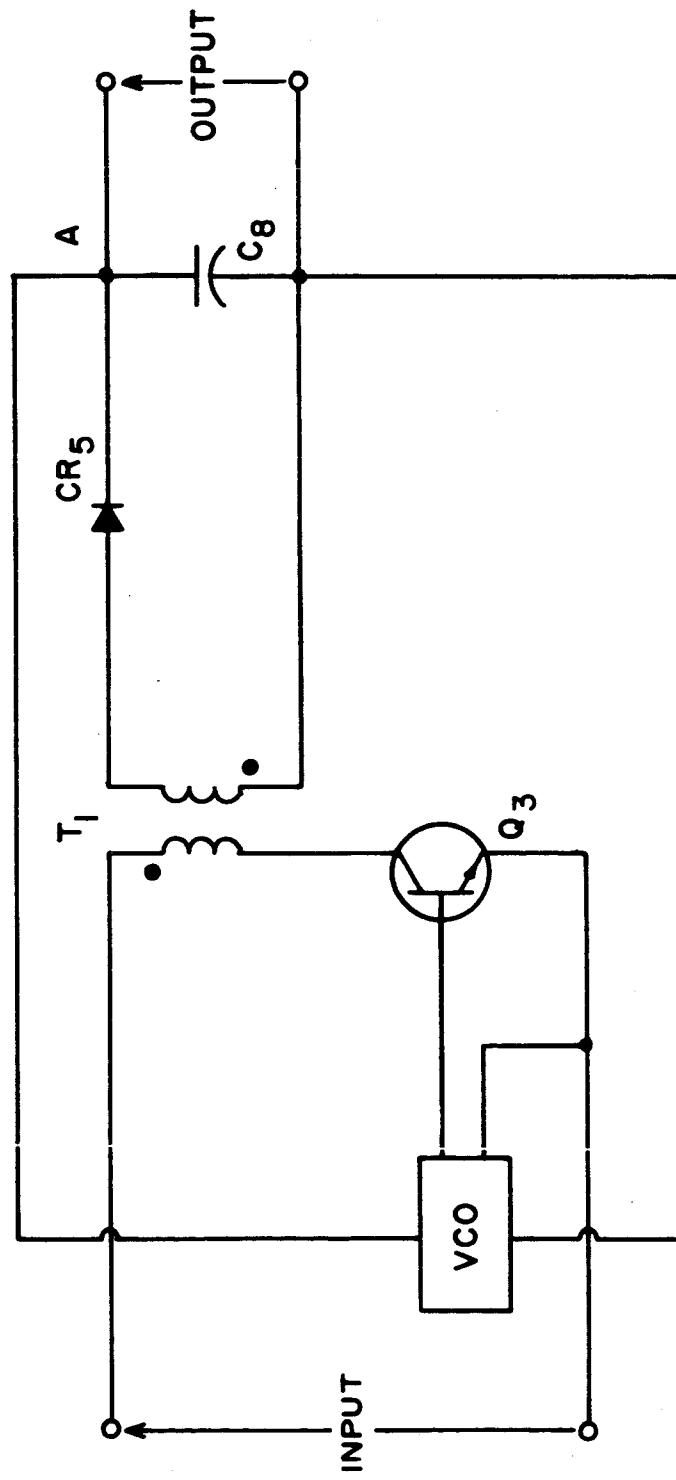


Fig. 3--Basic diagram of the 28-vdc power supply.

The voltage is further regulated, to approximately 0.1 percent, by a series regulator. A simplified diagram of this regulator is shown in Figure 4. When the voltage at the load increases, the sampling network detects this increase and feeds an error signal back to the amplifier. The amplifier, in turn, reduces the current into the base of the series element, transistor Q_8 , and causes the voltage at the load to decrease. In a similar manner if the voltage decreases, the current in the base of the series element increases and causes the load voltage to increase accordingly.

The starting circuit was incorporated in the power supply because in the isolated system the VCO has no starting voltage. The starting circuit voltage is generated in the RC network composed of capacitor C_4 and resistor R_1 of Figure 5, which causes the unijunction transistor Q_1 to conduct. This switching causes Q_2 to also conduct thus causing a voltage to appear on the secondary of transformer T_2 . This voltage provides the starting pulse for the VCO.

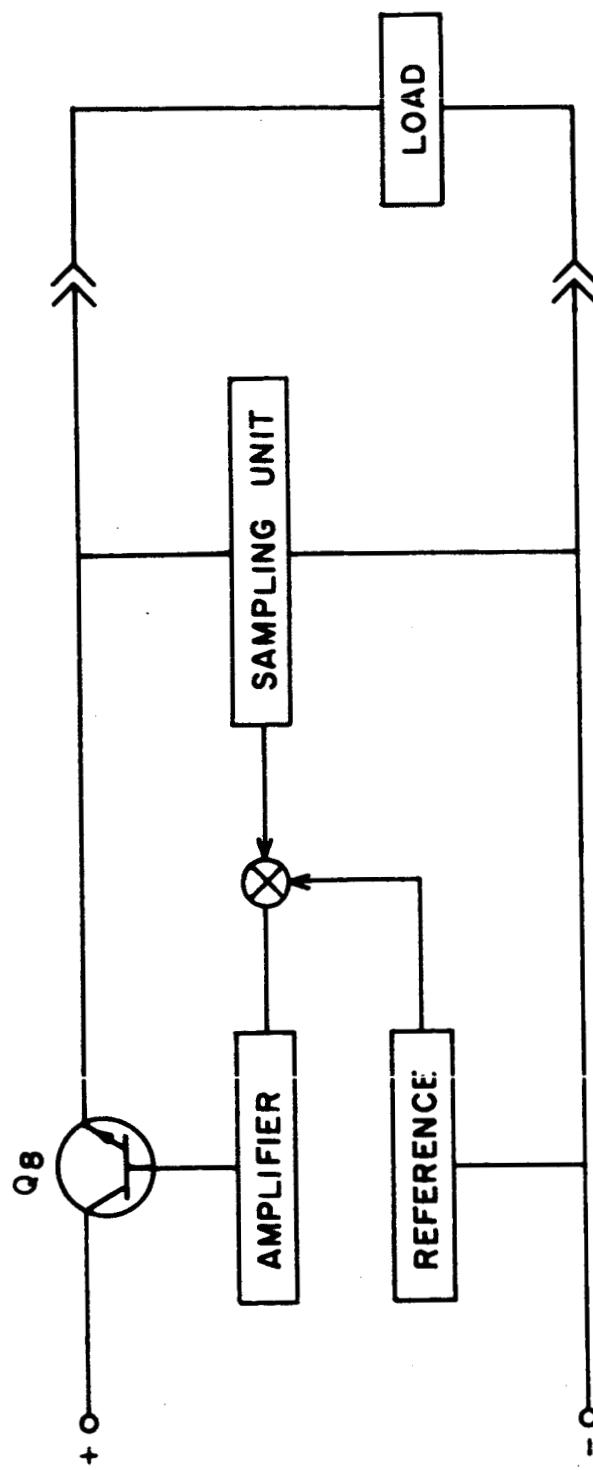


Fig. 4--Simplified diagram of the series regulator circuit.

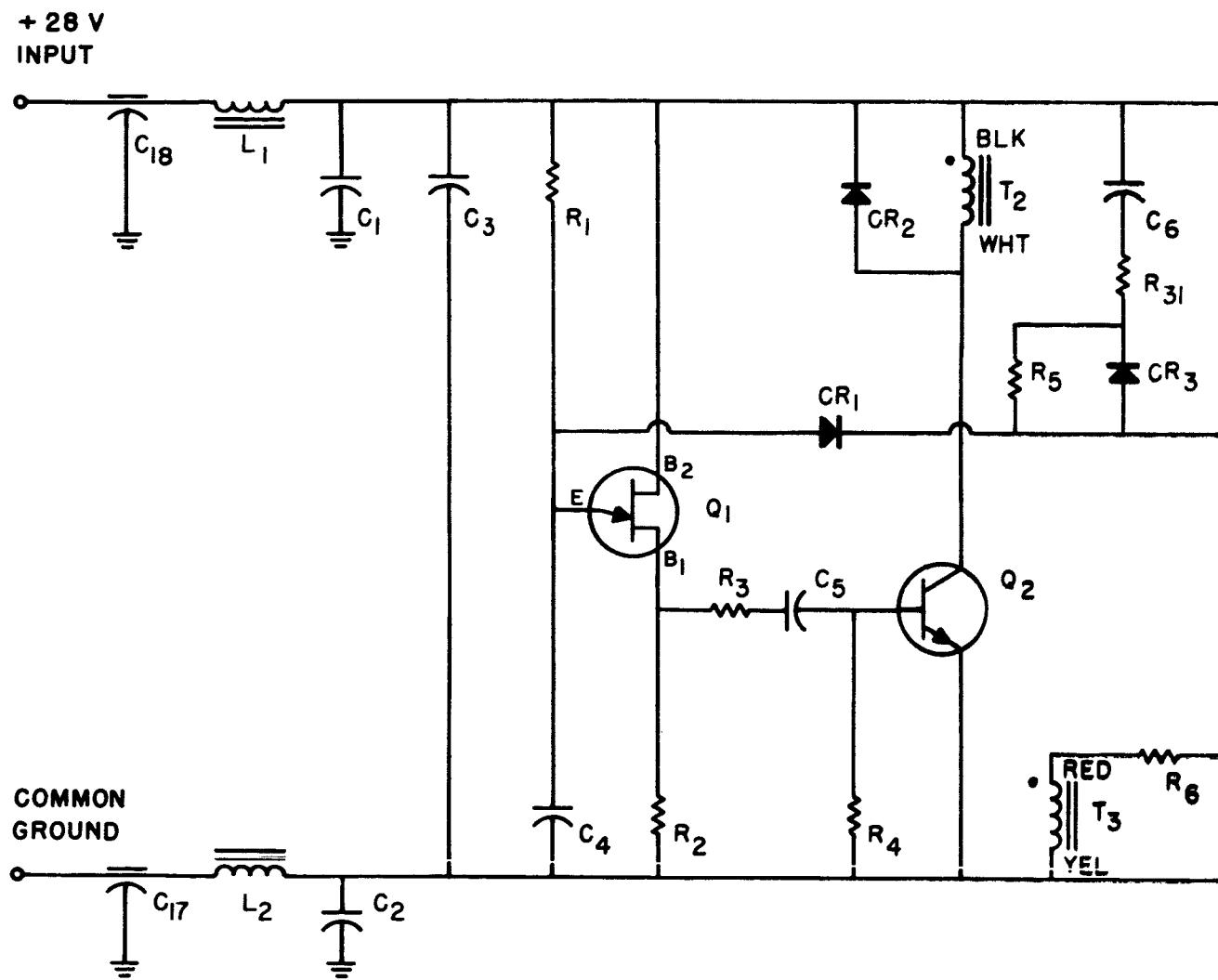
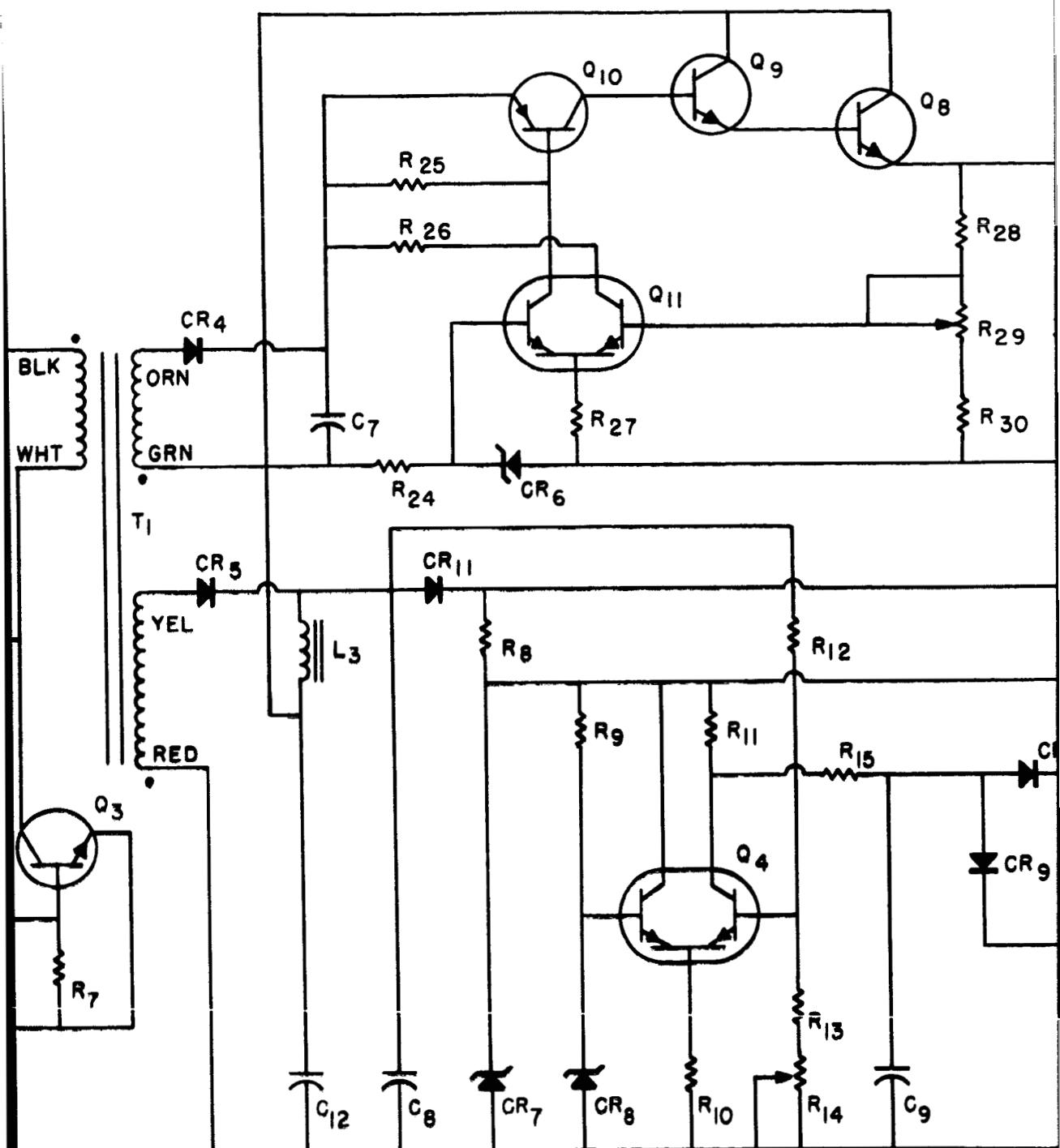


FIG. 5 - S



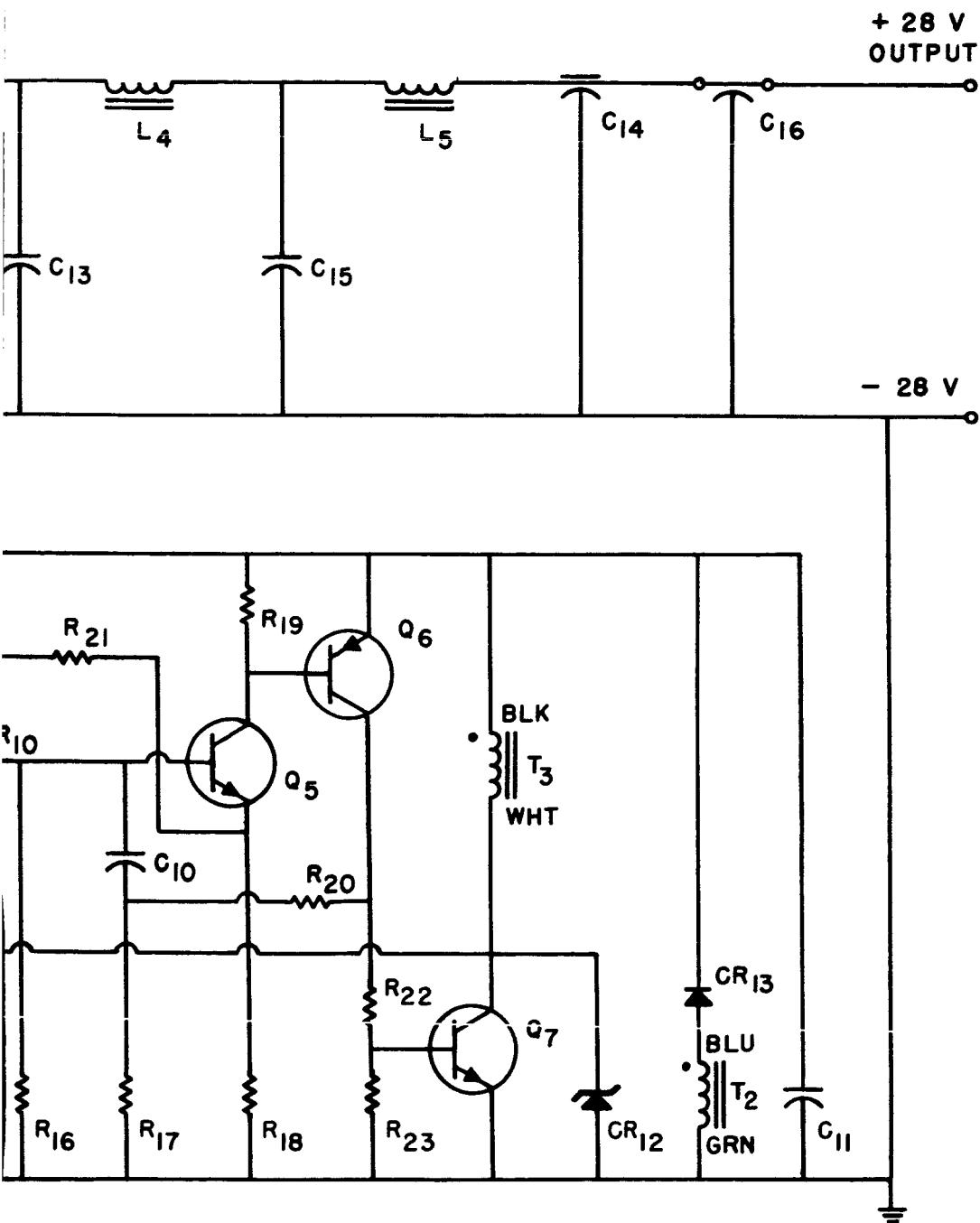


TABLE 3
CIRCUIT VALUES FOR THE 28-VDC POWER SUPPLY

Circuit Component	Component Value
R ₁	Fixed carbon resistor, 27000 ohm, 1/4 watt.
R ₂ , R ₄ , R ₁₇ , R ₂₃	Fixed carbon resistor, 1000 ohm, 1/4 watt.
R ₃	Fixed carbon resistor, 56 ohm, 1/4 watt.
R ₅	Fixed wirewound resistor, 300 ohm, 3 watt.
R ₆ , R ₃₁	Fixed wirewound resistor, 5.1 ohm, 3 watt.
R ₇	Fixed carbon resistor, 200 ohm, 1/4 watt.
R ₈	Fixed carbon resistor, 1100 ohm, 1/4 watt.
R ₉ , R ₁₂	Fixed carbon resistor, 5100 ohm, 1/4 watt.
R ₁₀	Fixed carbon resistor, 7500 ohm, 1/4 watt.
R ₁₁ , R ₂₅	Fixed carbon resistor, 10000 ohm, 1/4 watt.
R ₁₃	Fixed carbon resistor, 1300 ohm, 1/4 watt.
R ₁₄	Wirewound Potentiometer, 0-1000 ohm, 1/4 watt.
R ₁₅ , R ₃₀	Fixed carbon resistor, 12000 ohm, 1/4 watt.

TABLE 3
(continued)

Circuit Component	Component Value
R ₁₆	Fixed carbon resistor, 51000 ohm, 1/4 watt.
R ₁₈ , R ₂₀ , R ₂₁	Fixed carbon resistor, 3900 ohm, 1/4 watt.
R ₁₉	Fixed carbon resistor, 4300 ohm, 1/4 watt.
R ₂₂	Fixed carbon resistor, 2200 ohm, 1 watt.
R ₂₄	Fixed carbon resistor, 2700 ohm, 1/2 watt.
R ₂₆	Fixed carbon resistor, 36000 ohm, 1/4 watt.
R ₂₇	Fixed carbon resistor, 18000 ohm, 1/4 watt.
R ₂₈	Fixed carbon resistor, 30000 ohm, 1/4 watt.
R ₂₉	Wirewound Potentiometer, 0-5000 ohm, 1/4 watt.
C ₁ , C ₂	Fixed mica capacitor 0.04 mfd., 100-vdc.
C ₃ , C ₈ , C ₁₂	Fixed tantalum capacitor, 320 mfd., 100-vdc.
C ₄	Fixed tantalum capacitor, 3.3 mfd., 35-vdc.
C ₅	Fixed tantalum capacitor, 6.8 mfd., 35-vdc.
C ₆	Fixed mica capacitor, 0.02 mfd., 100-vdc.

TABLE 3
(continued)

Circuit Component	Component Value
C ₇	Fixed tantalum capacitor, 22 mfd. 35-vdc.
C ₉	Fixed mica capacitor, 10 pf., 100-vdc.
C ₁₀	Fixed mica capacitor, selected value.
C ₁₁	Fixed tantalum capacitor, 4.7 mfd. 50-vdc.
C ₁₃	Fixed tantalum capacitor, 1200 mfd. 50-vdc.
C ₁₄	Fixed tantalum feedthru capacitor, 6.8 mfd., 35-vdc.
C ₁₅	Fixed tantalum feedthru capacitor, 15 mfd., 50-vdc.
C ₁₆	Fixed ceramic standoff capacitor, 470 pf., 500-vdc.
C ₁₇ , C ₁₈	Fixed ceramic feedthru capacitor, 470 pf., 500-vdc.
Q ₁	Transistor type 2N491B.
Q ₂	Transistor type ZN2658.
Q ₃	Transistor type 2N2814.
Q ₄ , Q ₁₁	Transistor type 2N2060.
Q ₅	Transistor type 2N910.
Q ₆ , Q ₁₀	Transistor type 2N722.
Q ₇ , Q ₉	Transistor type 2N2102.
Q ₈	Transistor type 2N1724.

TABLE 3
(continued)

Circuit Component	Component Value
CR ₁ , CR ₉	Diode type 1N3071.
CR ₂ , CR ₃ , CR ₁₁ , CR ₁₃	Diode type RG100B.
CR ₄ , CR ₁₀	Diode type 1N3066.
CR ₅	Diode type 1N3881.
CR ₆ , CR ₈	Diode type 1N939A.
CR ₇	Diode type 1N967B.
CR ₁₂	Diode type 1N3040B.
L ₁ , L ₂	Core 55121-M4, 65 turns, AWG. No. 22.
L ₃	Core 55121-M4, 160 turns, AWG. No. 25.
L ₄	Core 55051-M4, 25 turns, AWG. No. 21.
L ₅	Fixed inductor, 3.3 microhenry, 1/4 watt.
T ₁	Core 55071-M4, Primary 68 turns, AWG. No. 19. Secondary 70 turns, AWG. No. 19. Secondary 15 turns, AWG. No. 26.
T ₂	Core 55310-M4, Primary 620 turns, AWG. No. 30. Secondary 560 turns, AWG. No. 30.
T ₃	Core 55206-M4, Primary 900 turns, AWG. No. 33. Secondary 166 turns, AWG. No. 26.

II. MILLIMETER WAVE STUDY

The vacuum equipment for the environmental chamber has been received. In addition, the platform which will support the chamber has been constructed. The absorbent material for lining the chamber has been received also.

A theoretical analysis of the lens system is being conducted. The object is to express mathematically the effect each lens has on the propagation of the electromagnetic waves. An additional set of lenses are being designed using Fresnel Zone Theory. These results will appear in future reports.